6-1-1968

Effects of Immediate Versus Delayed Knowledge of Results with Computer-Assisted Instruction

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EFFECTS OF IMMEDIATE VERSUS DELAYED KNOWLEDGE OF RESULTS WITH COMPUTER-ASSISTED INSTRUCTION

A Thesis

Presented to the

Department of Psychology

and the

Faculty of the Graduate College

University of Omaha

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

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June 1968

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Accepted for the faculty of the Graduate College of the University of Omaha, in partial fulfillment of the requirements for the degree Master of Arts.

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ACKNOWLEDGMENTS

The investigator extends his appreciation to:

Dr. John M. Newton, his advisor, for his continuous guidance and support in this research.

Dr. R. L. Wikoff, for his help with the experimental design and statistical analyses.

Dr. C. C. Kessler, for his logical insights which prevented my entrance into several blind alleys.

Mr. J. Niebaum, for his counsel and gracious assistance in the development of the experimental materials.

J. Ray and M. Everman, for their constant help in the conduct of the research.

Dr. L. A. Marsh, Abilene Christian College, for his academic and personal interest in the career of the investigator.

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INTRODUCTION

Bruner (1962) has suggested that more than ever before researchers are concerned with the techniques and devices that can be used to improve the educational enterprise. Some observers (Bundy, 1968; Finn, 1964) have expressed the idea that the educational world is in the early phases of a "permanent revolution" in which technology will play a major role. Bundy, (1968), has suggested that the evidence for such a "technological revolution" in education is perhaps nowhere more evident than in recent research dealing with programmed instruction and especially computer-assisted instruction (CAI).

The increasing use of a computer to present instructional materials to an individual is, in part, an outgrowth of research on programmed instruction. In fact, CAI is based on many of the same theoretical foundations as is programmed instruction. Even though significant developments in programmed learning and CAI have occurred within recent years, the concepts involved are not completely new. The statement by Ebbinghaus that "psychology has a long past, but a short history" (Boring, 1950) is equally applicable to programmed instruction and CAI.

Beginning about 1920, Sidney Pressey attempted to mechanize testing and teaching. Pressey (1926) published

an article describing a machine that provided automatic scoring of multiple choice tests. The machine also gave feedback to an individual indicating the correctness of each answer, and was used for teaching drill materials. As Silverman (1964) suggested, however, the Zeitgeist was not ready and Pressey's device had little impact upon the educational world. For approximately three decades thereafter, research dealing with teaching machines was practically nonexistent.

In an article by B. F. Skinner (1954) the concept of the teaching machine was reintroduced to the educational world. Skinner proposed ways in which learning principles, derived from studies with lower animals, could be applied to the education of humans. Skinner even suggested that some of the learning principles could be applied more effectively by an automatic teaching machine than by a human teacher. Abma (1967) suggested that, through the application of principles of reinforcement and successive approximations, Skinner has provided the most ambitious attempt to overhaul traditional means of educational instruction.

As Gleason (1967) indicated, interest in CAI was stimulated, in part, by some of the short-comings in conventional programmed instruction. Many advantages of CAI over programmed instruction have been reported and the following

three reported by Gleason are typical:

1. ... CAI systems utilize a wide variety of response modes...
2. These systems also provide for a wide variety of student response modes...
3. These systems provide truly immediate feedback...

Reported research has indicated that students seem to learn as well with CAI as with conventional classroom instruction, and that in some instances greater learning and retention can occur with CAI (Bitzer, 1963; Grubb and Selfridge, 1964; Schurdak, 1965). Research has also indicated that CAI can significantly reduce learning time in certain instances (Grubb and Selfridge, 1964; Uttal, 1962; Wing, 1964).

One of the major learning principles upon which programmed instruction and CAI is based is that of immediate knowledge of results (Gleason, 1967; Skinner, 1954). For approximately fifty to sixty years numerous learning studies dealing with lower animals, human motor skills and nonsense verbal material have reported the superiority of immediate knowledge of results over delayed knowledge of results (Ammons, 1956; Landsman, 1962; Renner 1964). It is this general finding that has been used to support the contention that teaching machines should incorporate the principle of immediate knowledge of results in order to be maximally effective for learning.

Recent studies have indicated that when careful consideration is given to the type of learning and organism involved, unequivocal acceptance of the principle of immediate knowledge of results may not be justified (Brackbill, Isaacs, & Smelkenson, 1962; Brackbill, Wagner, & Wilson, 1964). In a verbal learning task, English and Kinzer (1966) found one-hour delay and two-day delay of feedback superior to immediate and one-week delay of feedback. Using an apparatus simulating a teaching machine and investigating the effects of immediate versus a 10 sec. delay of feedback, Brackbill, Wagner, & Wilson (1964) found delayed feedback just as effective for learning as immediate feedback and that delayed feedback was more effective than immediate for the retention of difficult materials. Moore and Smith (1962), in a series of experiments designed to test the effectiveness of the principle of immediate knowledge of results in programmed learning, failed to find that knowledge of results facilitated learning. In a study more closely resembling that of a CAI setting, Boersma (1966) presented materials to subjects via the MTA Scholar teaching machine and investigated the effects of two levels of delay of knowledge of results: 0, and 8 sec., on performance. Using response latency and objective test scores as criteria, Boersma failed to find a significant level of delay effect. It should be pointed out, however, that much of the above research differed from CAI in that feedback was not always presented to the learner,

and that a multiple choice format was used in many instances instead of an overt constructed response.

Because of the fact that CAI is practical only under time-sharing conditions and since past research (Bitzer et al., 1962) has indicated that students become confused in such conditions, the present investigator believed that an investigation of immediate versus delayed knowledge of results with CAI would be of practical benefit in the designing of computer-based instructional systems in the future.

Pilot Study

A pilot study was conducted by the experimenter during the Fall semester of 1967 at the University of Omaha. The purpose of the study was the investigation of the effects of immediate versus delayed knowledge of results and sex on performance with CAI. Two levels of delay were investigated: 0 and 7 sec.. Twelve males and 12 females were used and performance was measured by the difference score obtained between a pretest and posttest. The program dealt with the experimental method in psychology and was developed by the investigator. Results of the study indicated a significant delay effect at the .05 level. Investigation of the mean difference scores for the 0 and 7 sec. groups showed the seven sec. delay group to be superior in performance. An attitude questionnaire dealing with attitude toward CAI was administered to the subject after completion of the computer program. Results of the Mann-Whitney U test

failed to indicate a significant difference in attitude scores between groups receiving immediate and delayed knowledge of results.

Problem

Because of the negative findings dealing with the effectiveness of the principle of immediate knowledge of results in programmed instruction, and specifically the paucity of such research with CAI, further research seemed warranted. The purpose of the present experiment was to investigate the effects of immediate versus delayed knowledge of results with CAI. The effects of sex were also investigated because past research (Boersma, 1966), in a similar learning situation had found it to be a relevant variable. Reported research (Mitzel and Wodke, 1965) had also indicated that attitude toward CAI was directly related to performance in such a situation, and a secondary purpose of the study was the investigation of the effects of level of delay and sex on attitude toward CAI. In line with past research (Boersma, 1966) and since such delays are fairly common in CAI time-sharing situations, three intervals of delay were chosen for investigation: 0, 4, and 8 seconds.

Hypotheses

The present study had two independent variables: delay of knowledge of results, and sex. The dependent variables were objective test scores, time to complete the program, program scores, and attitude scores.

Hypothesis 1. There will be no significant delay of knowledge of results effect, sex effect, or interaction effects for test scores.

Hypothesis 2. There will be no significant delay of knowledge of results effect, sex effect, or interaction effects for time scores.

Hypothesis 3. There will be no significant delay of knowledge of results effect, sex effect, or interaction effects for program scores.

Hypothesis 4. There will be no significant delay of knowledge of results effect, sex effect, or interaction effects for attitude scores.

METHOD

Subjects

All subjects were volunteers enrolled in an introductory psychology course in the Spring of 1968 at the University of Omaha. Each student is required to participate in a specified number of hours of experimentation. Sixty males were randomly assigned to one of the three levels of delay and the procedure was repeated for females. The subjects ranged in age from 18 years to 29 years of age with a mean age of 20.42 for males and 19.56 for females. None of the subjects had been or were enrolled in the college mathematics course entitled Logic, Sets, and Functions offered at the University of Omaha. Because of mechanical and scheduling difficulties, seven subjects had to be replaced. This was accomplished by random assignment of seven additional subjects from the introductory psychology course.

Materials

A seventeen-frame constructed response program was used under all experimental conditions with only the interval of delay being changed for each experimental condition. The program was written in the computer language Computest (Starkweather, 1965) and was presented to the subject by an IBM 1620 computer, which has an input-output terminal very similar to a standard typewriter. The interval of delay was defined as the time elapsing between the termination

of a students' input, in response to a question presented by the computer, and the computer presenting knowledge of results to the student. Immediate knowledge of results was operationally defined as the time interval between input and receiving knowledge of results with the computer scanning its memory at the rate of 160 characters per second. The desired level of delay of knowledge of results, either 4, or 8 sec., was achieved by modification of the Computest object deck. A detailed explanation of how this was achieved is presented in Appendix (A).

The program presented by the computer dealt with binary relations and was a revision of one developed by a graduate student in mathematics at the University of Omaha. A copy of the program, written in Computest is presented in Appendix (B).

An eleven-item multiple choice achievement examination dealing with the material presented by the computer was used as a measure of teaching effectiveness in the experiment. It was believed that the test would provide additional information other than that available from an analysis of the program itself and perhaps give an indication of the amount of short-term retention resulting from the program. A copy of this test is included in Appendix (C).

A forty item (Likert-type) attitude questionnaire developed by Brown (1966) was used in the experiment as a measure of expressed attitude toward CAI. The KR 20 coefficient of reliability reported by the author for this

instrument was .885. No statistical evidence for the validity of the instrument was available. A copy of the questionnaire is presented in Appendix (D).

Procedure

A fixed-effects model was used for the analyses. A 2 X 3 factorial analysis of variance design was used to test the main effects and interaction effects of the independent variables.

Each subject participated in the experiment at a time in which his class schedule allowed. Only one subject participated at a session and all sessions were proctored by the experimenter. When the subject arrived at the session, he was seated at the computer and the experimenter read to the subject a set of procedural instructions (Appendix E). The subject then completed the program dealing with binary relations presented by the computer. Upon completion of the program, the subject was administered the forty item attitude questionnaire and then the eleven item multiple choice achievement test. The subjects time taken to complete the program and the program score were also recorded. When the subject had completed the entire procedure the experimenter gave the subject credit for the experiment, thanked him, and then dismissed the subject. Each experimental session lasted approximately thirty to forty minutes.

RESULTS

The performance of the six groups was compared on the basis of four criteria: the number of correct responses on the multiple choice achievement test; time taken to complete the program; number of correct responses on the program; and scores received on the attitude questionnaire. The group means for all of these criteria are presented in Table 1.

Table 1

Group Means for the Four Criteria

	0 sec.		4 sec.		8 sec.	
	Male	Female	Male	Female	Male	Female
Test Scores	6.00	5.85	7.15	5.80	5.60	5.85
Time Scores	16.20	15.35	16.32	13.57	15.69	15.19
Program Scores	84.45	81.55	79.40	83.05	86.10	78.05
Attitude Scores	148.70	145.45	150.60	148.85	155.75	137.40

The summary for the analysis of variance of test scores is presented in Table 2. As the data indicate, the test scores were found to be insensitive to the manipulation of the independent variables. In other words, there was no significant difference in performance among groups receiving knowledge of

results after a 0, 4, or 8 sec. delay. Also there was no significant sex effect or interaction effect between delay of knowledge of results and sex.

Table 2

Analysis of Variance Summary for Test Scores

Source	d.f.	S.S.	M.S.	F
A (level of delay)	2	12.066	6.033	1.597
B (sex)	1	5.208	5.208	1.363
A X B	2	13.866	6.933	1.814
Error	114	435.650	3.821	
Total	119	466.791		

Because the findings in regard to test scores were somewhat surprising to the investigator, an item analysis was performed for the multiple choice achievement test. Results indicated that all but two of the 11 items were of appropriate difficulty, and that all but three items discriminated satisfactorily (Appendix F). The KR 20 coefficient of reliability for the test was found to be .44. An index of skewness of .03 was obtained for the distribution of test scores (Garrett, 1958).

Analysis of the time scores revealed no significant delay of knowledge of results effect or significant interaction between delay of knowledge of results and sex, but did indicate a significant sex effect at the .005 level.

Inspection of the mean time scores for males and females revealed them to be 16.07 and 14.08 respectively, indicating that males spent a significantly longer amount of time on the program than did females. The summary for the analysis of variance of time scores is presented in Table 3.

Table 3

Analysis of Variance Summary for Time Scores

Source	d.f.	S.S.	M.S.	F
A (level of delay)	2	9.248	4.624	0.788
B (sex)	1	48.133	48.133	8.197*
A X B	2	26.616	10.808	1.841
Error	114	669.400	5.871	
Total	119	748.398		

* Significant at the .005 level

When the program scores were subjected to analysis no significant main effects for delay of knowledge of results or sex were evident, and no significant interaction between the two variables was present. The summary for the analysis of variance of program scores is presented in Table 4.

Table 4

Analysis of Variance Summary
for Program Scores

Source	d.f.	S.S.	M.S.	F
A (level of delay)	2	63.050	31.520	0.25
B (sex)	1	177.633	177.633	1.42
A X B	2	187.717	93.858	0.75
Error	114	14192.400	124.494	
Total	119	14620.800		

An analysis of the attitude scores revealed no significant main effect for delay of knowledge of results, but did indicate a significant sex main effect at the .01 level, and a significant interaction between delay and sex at the .05 level. The summary for the analysis of variance of attitude scores is presented in Table 5.

Table 5

Analysis of Variance Summary
for Attitude Scores

Source	d.f.	S.S.	M.S.	F
A (level of delay)	2	232.200	116.100	0.475
B (sex)	1	1801.875	1801.875	7.372**
A X B	2	1695.200	847.600	3.468*
Error	114	27865.650	244.435	
Total	119	31594.925		

**Significant at the .01 level
*Significant at the .05 level

The significant interaction found between delay of knowledge of results and sex, in regard to attitude scores, was investigated further by means of an analysis of simple effects. Simple effects for sex were tested at each level of delay. The results are presented in Table 6, and these data indicate that the simple effects of sex were significant for the eight second delay.

Table 6

Analysis of Variance Summary for Simple Effects

Source	d.f.	S.S.	M.S.	F
Sex at 0 sec.	1	99.23	99.23	0.40
Sex at 4 sec.	1	30.69	30.69	0.12
Sex at 8 sec.	1	3367.23	3367.23	13.78**
Error	114	27865.65	244.43	

**Significant at the .001 level

Although no specific hypotheses were made a priori in regard to the relationship between time scores and attitude scores, because of the significant sex main effect found for each of those dependent variables, a correlational analysis (n=120) was computed for the two factors. The Pearson product-moment coefficient was -.057 and not significant. A product-moment coefficient was also computed for the two factors in regard to sex. The coefficient for males (n=60)

was -.08 and for females (n=60) .09. Neither of the coefficients was significant.

Incorporated in the experimental program was a "help sequence" designed to enable the subject to seek assistance from the computer whenever the answer to a particular frame could not be determined by the subject. If the subject needed help, he could simply type the word "help" on the keyboard of the input-output terminal and the computer supplied background information and the correct answer to that particular frame. The "help sequence" was used a total of 37 times and a Chi Square analysis of the number of help responses revealed no significant differences in the number of times the sequence was used among groups receiving immediate and delayed knowledge of results.

DISCUSSION AND CONCLUSIONS

The finding that there was no significant difference, in test scores, among groups receiving immediate knowledge of results and groups receiving delayed knowledge of results supported similar past research (Boersma, 1966), but contradicted results obtained by the experimenter in a pilot study. A possible explanation for the contradictory findings may be the methodological differences involved between the two studies. In the pilot study, because of the subjects' previous familiarity with the program, the criterion measure used was the difference score obtained between pretest and posttest. Also, since the same instrument was used for the pretest and posttest, transfer effects may have occurred. Although the item analysis and index of skewness for the achievement test, in the present study, revealed it to be of sufficient difficulty and the distribution of test scores not significantly skewed, the obtained KR 20 coefficient of .44 was less than had been anticipated by the experimenter. This finding was considered as a possible source of experimental error contributing to the overall error variance and thus a possible explanation for the failure to find a significant level of delay of knowledge of result effect.

The finding that males took significantly longer than females to complete the program supported similar past research (Boersma, 1966). Since there was no significant

correlation between time and attitude scores for males or females, the difference could not be explained in terms of attitude toward CAI. Although there was no experimental basis for it, the experimenter speculated that perhaps females had had more typing experience and thus benefited from positive transfer causing them to complete the program more rapidly. Past research has, however, indicated a positive relationship between time taken to complete a CAI program and scholastic achievement(Stolurow, 1965), and the experimenter suggests that such relationships be investigated in future CAI studies.

It was hypothesized that there would be no significant interaction between delay of knowledge of results and sex for any of the attitude scores. This hypothesis was not supported. Since there were no significant sex main effects or simple effects for program scores, the finding that males had better attitude scores than did females for the eight sec. level of delay could not be interpreted in terms of better performance on the program by either sex. The experimenter speculated that the mathematical nature of the program may have been a third variable contributing to such an interaction. As the level of delay increased, male attitudes may have been sustained by more of an interest in the material presented.

The experimenter speculated that college students and adults may possess more of an ability to verbally mediate across time, than do children and lower animals, and thus

short intervals of delay with CAI may have no significant effect on performance with such individuals. Because of the brevity of the experimental program and low reliability of the criterion test, however, this speculation is somewhat suspect and the investigator agrees with Bundy (1968) that future CAI studies should give more consideration to the length of the program and measures of long-term retention. Also, because of the significant sex main effects found for two of the dependent variables, it is recommended that future studies of CAI give more consideration to the effects of sex on performance.

The major findings of the present investigation were:

1. In regard to test score performance, there were no significant effects due to delay of knowledge of results or sex.

2. Males took significantly longer to complete the program than did females.

3. Males had significantly more favorable attitudes toward CAI than did females at the eight second level of delay.

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APPENDIX A

The Computest object deck, designed for use with the IBM 1620, Model I, was modified in the following manner:

The four second level of delay was achieved by changing columms 37 to 48 of card number 68 in the object deck to read 491991800000, and by inserting two new cards between cards 120 and 121 with the following numbers:
3717999001001619948000016186111994800012419948199534719954013004903796

The eight second level of delay was achieved in exactly the same manner except by changing columns 32 to 36 of the first card inserted after card 120 to read 3093.

APPENDIX B

CIN MATHEMATICS A SET IS REFERRED TO AS A WELL DEFINED COLLECTION OF
COBJECTS OR ELEMENTS. WELL DEFINED JUST MEANS THAT IT IS POSSIBLE TO
CDETERMINE READILY WHETHER AN OBJECT IS A MEMBER OF THE SET OR NOT.
C
CCONSIDER THE COLLECTION OF THE FIFTY STATES IN THE UNITED STATES. THIS
CCOLLECTION COULD BE CALLED A ... , IN WHICH EACH STATE IS AN ELEMENT.
R SET
GTHATS RIGHT
AA RSKIP 1, SCORE 1
R HELP
GREMEMBER NOW, WE SAID A WELL DEFINED COLLECTION OF OBJECTS OR ELEMENTS
GIS A SET. SO THE COLLECTION OF FIFTY STATES WOULD BE A SET.
BNO. REMEMBER WE SAID A WELL DEFINED COLLECTION OF OBJECTS OR ELEMENTS
BIS A SET. SO THE COLLECTION OF FIFTY STATES WOULD BE A SET.
AA RESCAN, SCORE 2
C
CWOULD YOU SAY THAT THE SET OF THE FIVE MOST POPULAR SINGERS IN AMERICA
CIS WELL DEFINEDQ
R NO
GYOURE RIGHT. BECAUSE PEOPLES OPINIONS VARY SO MUCH, IT IS NOT VERY EASY
GTO DETERMINE JUST WHO WOULD BE A MEMBER OF THIS SET.
AA RSKIP 1, SCORE 1
R HELP
GWELL, IT CANNOT BE READILY DETERMINED WHICH SINGERS WOULD FIT INTO THIS
GSET BECAUSE PEOPLES OPINIONS VARY SO MUCH. THEREFORE, THIS PARTICULAR
GSET WOULD NOT BE WELL DEFINED.
BNO THATS NOT RIGHT. IT CANNOT BE READILY DETERMINED WHICH SINGERS WOULD
BFIT INTO THIS SET BECAUSE PEOPLES OPINIONS VARY SO MUCH.
AA RESCAN, SCORE 2

```
C
CTHINK ABOUT THE UNITED STATES SENATE. IT IS A COLLECTION OF INDIVIDUALS
CAND COULD BE REFERRED TO AS A ...
R     SET
GGOOD
AA    RSKIP 1, SCORE 1
R     HELP
GIF THE SENATE IS A COLLECTION OF INDIVIDUALS, THEN FROM OUR DISCUSSION
GSO FAR, YOU SHOULD KNOW THAT IT COULD BE CALLED A SET.
BIF THE SENATE IS A COLLECTION OF INDIVIDUALS, THEN FROM OUR DISCUSSION
BSO FAR, YOU SHOULD KNOW THAT IT COULD BE CALLED A SET. PAY A LITTLE
BMORE ATTENTION FROM NOW ON.
AA    RESCAN, SCORE 2
C
CTHE INDIVIDUAL SENATORS WOULD BE CALLED THE E... OF THE SETQ
R     ELEMENTS
GCORRECT. THE SENATORS MAKE UP THIS SET, SO THEY ARE THE ELEMENTS OR
GOBJECTS OF THE SET.
AA    RSKIP 1, SCORE 1
R     HELP
GIF THE SENATORS MAKE UP THIS SET, THEN THEY WOULD BE CALLED ELEMENTS OR
GOBJECTS. THE THINGS THAT MAKE UP A SET ARE REFERRED TO AS ITS ELEMENTS.
BNO. IF THE SENATORS MAKE UP THIS SET, THEN THEY WOULD BE CALLED
BELEMENTS OR OBJECTS. THE THINGS THAT MAKE UP A SET ARE REFERRED TO AS
BITS ELEMENTS.
AA    RESCAN, SCORE 2
C
CIN THE THREE EXAMPLES OF SETS WE HAVE DISCUSSED SO FAR, THE ORDER OF
CTHE ELEMENTS OF THE SET HAS NOT BEEN PARTICULARLY IMPORTANT. ANOTHER
```

CEXAMPLE OF SUCH A CASE WOULD BE A DECK OF CARDS. THE DECK OF CARDS IS A CSET OF 52 INDIVIDUAL CARDS. EACH CARD IS REFERRED TO AS AN ... OF THE CSET.

R ELEMENT

GVERY GOOD

AA RSKIP 1, SCORE 1

R HELP

GTHINK ABOUT OUR DISCUSSION SO FAR. THE THINGS THAT COMPRISE OR MAKE UP GA SET ARE CALLED ITS ELEMENTS. IF THE TOTAL DECK OF CARDS IS A SET, GTHEN THIS SET HAS 52 ELEMENTS BECAUSE THERE ARE 52 CARDS IN A DECK OF GCARDS.

BNO THATS INCORRECT. THINK ABOUT OUR DISCUSSION SO FAR. THE THINGS THAT BCOMPRISE OR MAKE UP A SET ARE CALLED ITS ELEMENTS. IF THE TOTAL DECK OF BCARDS IS A SET, THEN THIS SET HAS 52 ELEMENTS BECAUSE THERE ARE 52 BCARDS IN THE TOTAL DECK.

AA RESCAN, SCORE 2

C

CWHEN YOU SHUFFLE AND RESHUFFLE THE DECK, THE ORDER OF THE ELEMENTS CCHANGES, BUT DO THE ELEMENTS THEMSELVES CHANGEQ ANSWER YES OR NO.

R NO

GTHATS RIGHT. YOU STILL HAVE THE SAME DECK OF CARDS YOU HAD TO BEGIN GWITH.

AA RSKIP 1, SCORE 1

R HELP

GREMEMBER NOW, NO MATTER WHAT ORDER THE CARDS APPEAR IN, AFTER YOU HAVE GSHUFFLED THEM, YOU STILL HAVE THE SAME DECK OR SET OF CARDS.

BNO THATS NOT RIGHT, BECAUSE NO MATTER WHAT ORDER THE CARDS APPEAR IN, BAFTER YOU HAVE SHUFFLED THEM, YOU STILL HAVE THE SAME DECK OR SET OF BCARDS.

AA RESCAN, SCORE 2

C

CAS YOU HAVE SEEN THEN, IN SOME SETS, THE ORDER OF THE ELEMENTS MAY NOT CRE IMPORTANT. IN SOME SETS, HOWEVER, THE ORDER OF THE ELEMENTS IS CIMPORTANT. IN OUR DISCUSSION FROM NOW ON, WE ARE GOING TO WORK WITH CSETS IN WHICH THE ORDER OF THE ELEMENTS IS IMPORTANT.

C

CTHE PARTICULAR SETS WE ARE GOING TO DISCUSSS FIRST CONSIST OF ONLY TWO CELEMENTS. THESE ARE CALLED ORDERED PAIRS, AND ARE SETS OF TWO ELEMENTS CFOR WHICH IT HAS BEEN DECIDED WHICH IS FIRST IN THE PAIR AND WHICH IS CSECOND.

C

CAN ORDERED PAIR IS WRITTEN (A,B). A AND B ARE THE ... OF THE ORDERED CPAIR.

R ELEMENTS

GGOOD

AA RSKIP 1, SCORE 1

R HELP

GWELL, YOU SHOULD BE ABLE TO TELL THAT A AND B ARE THE ELEMENTS OF THIS GORDERED PAIR.

BNO THATS NOT RIGHT, YOU SHOULD BE ABLE TO TELL THAT A AND B ARE THE BELEMENTS OF THIS ORDERED PAIR.

AA RESCAN, SCORE 2

C

CCONSIDER THE ORDERED PAIR (HUSBAND,WIFE) IN WHICH THE HUSBAND ALWAYS CCOMES FIRST. SPECIFIC EXAMPLES OF THIS ORDERED PAIR ARE (LYNDON,LADY CBIRD) (PRINCE PHILLIP,QUEEN ELIZABETH) (ANTHONY,CLEOPATRA) AND C(ADAM,...) SUPPLY THE MISSING WORD.

R EVE

GRIGHT

AA RSKIP 1, SCORE 1

R HELP

GWELL, I WAS LOOKING FOR THE WIFE OF ADAM. IN THIS ORDERED PAIR IT WOULD GBE EVE.

BNO. I WAS LOOKING FOR THE WIFE OF ADAM. IN THIS ORDERED PAIR IT WOULD BBE EVE.

AA RESCAN, SCORE 2

C

CDOES (CHER,SONNY) BELONG WITH THE PRECEEDING EXAMPLES OF THE ORDERED CPAIR (HUSBAND,WIFE)Q

R NO

GRIGHT I BELIEVE YOURE GETTING THE POINT

AA RSKIP 1, SCORE 1

R HELP

GWELL, SONNY IS THE HUSBAND OF CHER SO THE ORDERED PAIR (CHER,SONNY) GWOULD NOT BE AN EXAMPLE OF THE ORDERED PAIR (HUSBAND,WIFE).

BCAUGHT YOU NAPPING DIDNT I. IN THIS ORDERED PAIR THE HUSBAND HAS TO BALWAYS COME FIRST. SONNY IS THE HUSBAND OF CHER SO THE ORDERED PAIR B(CHER,SONNY) WOULD NOT BE AN EXAMPLE OF (HUSBAND,WIFE). HOWEVER, B(SONNY,CHER) WOULD BE AN EXAMPLE OF THE ORDERED PAIR (HUSBAND,WIFE).

AA RESCAN, SCORE 2

C

CTHESE EXAMPLES HAVE SHOWN HOW ELEMENTS OF AN ORDERED PAIR CAN BE CRELATED. ORDER IS IMPORTANT BECAUSE IF YOU CONSIDER THE ORDERED PAIR C(X,Y) WHERE X IS THE MOTHER OF Y, YOU CANNOT CHANGE IT AROUND TO C(Y,X) WHERE Y IS THE ... OF X AND HAVE IT MEAN THE SAME THING.

R MOTHER

GRIGHT

AA RSKIP 1, SCORE 1

R HELP

GWELL(IF YOU TURNED IT AROUND, Y WOULD BE THE MOTHER OF X, AND THIS GWOULD NOT FIT OUR ORDERED LPAIR.

BNO. IF YOU TURNED IT AROUND, Y WOULD BE THE MOTHER OF X, AND THIS WOULD BNOT FIT OUR ORDERED PAIR.

AA RESCAN, SCORE 2

C

CELEMENTS CAN ALSO BE RELATED IN OTHER WAYS. SOME OF THE WAYS ARE CLARGER THAN, LESS THAN, DIVIDED BY, AND TIMES. ARE THE ELEMENTS OF THE CORDERED PAIR (N,N2) RELATEDQ ANSWER YES OR NO.

R YES

GCORRECT. THE SECOND ELEMENT IS THE SQUARE OF THE FIRST.

AA RSKIP 1, SCORE 1

R HELP

GTHE ANSWER IS YES. THE SECOND ELEMENT IS THE SQUARE OF THE FIRST.

BYES THEY ARE TOO. THE SECOND ELEMENT IS THE SQUARE OF THE FIRST.

AA RESCAN, SCORE 2

C

CCONSIDER AN ORDERED PAIR IN WHICH THE FIRST ELEMENT IS LESS THAN THE CSECOND ELEMENT. WOULD THE ELEMENTS OF (2,3) BE RELATED IN THIS WAYQ

R YES

GYOURE RIGHT

AA RSKIP 1, SCORE 1

R HELP

GYES THEY WOULD. 2 IS LESS THAN 3 WHICH IS HOW THESE ELEMENTS ARE GRELATED. ANY ORDERED PAIR SUCH AS (2,4) (4,6) AND (3,8) WOULD BE GRELATED IN THIS WAY.

BNO THATS WRONG. 2 IS LESS THAN 3 WHICH IS HOW THESE ELEMENTS ARE

BRELATED. ANY ORDERED PAIR SUCH AS (2,4) (4,6) AND (3,8) WOULD BE BRELATED IN THIS WAY.

AA RESCAN, SCORE 2

C

CWOULD THE ELEMENTS OF(5,4) BE RELATED IN THAT THE FIRST IS LESS THAN CTHE SECOND?

R NO

GRIGHT AGAIN.

AA RSKIP 1, SCORE 1

R HELP

GIN THIS CASE 5 IS GREATER THAN 4 SO THEY WOULD NOT BE RELATED IN THAT GTHE FIRST ELEMENT IS LESS THAN THE SECOND.

BNO THATS WRONG. IN THIS CASE 5 IS GREATER THAN 4 SO THEY WOULD NOT BE BRELATED IN THAT THE FIRST ELEMENT IS LESS THAN THE SECOND.

AA RESCAN, SCORE 2

C

CNOW PAY CLOSE ATTENTION TO THE FOLLOWING BECAUSE IT IS ESSENTIAL TO OUR CDISCUSSION.

C

CWHEN A SET CONSISTS OF ORDERED PAIRS IN WHICH THE ELEMENTS OF EACH PAIR CARE RELATED TO EACH OTHER IN THE SAME WAY, WE HAVE WHAT IS CALLED A CBINARY RELATION.

CBINARY REFERS TO ORDERED PAIRS WHICH CONTAIN TWO ELEMENTS.

C*(1,2) (2,3) (3,4)* IS A SET OF ORDEREDPAIRS WITH EACH PAIR HAVING CTWO ELEMENTS RELATED TO EACH OTHER IN THE SAME WAY. THEREFORE IT IS A

C... ...

R2 BINARY RELATION

GRIGHT. IT IS A SET OF ORDERED PAIRS, WITH EACH PAIR CONTAINING TWO GELEMENTS RELATED IN THE SAME WAY AND IS CALLED A BINARY RELATION.

```
AA     RSKIP 1, SCORE 1
R      HELP
GWELL, AS YOU CAN SEE, IT IS A SET OF ORDERED PAIRS WITH EACH PAIR
GCONTAINING TWO ELEMENTS RELATED IN THE SAME WAY. THEREFORE IT IS A
GBINARY RELATION.
BNO THATS INCORRECT. AS YOU CAN SEE( IT IS A SET OF ORDERED PAIRS WITH
BEACH PAIR CONTAINING TWO ELEMENTS RELATED IN THE SAME WAY. THEREFORE
BIT IS A BINARY RELATION.
AA     RESCAN, MATCH 2, SCORE 2
C
C A RELATION COULD BE DEFINED AS A S.. OF ...  ...
R3     SET        ORDERED   PAIRS
GCORRECT
AA     MATCH 3, RSKIP 1, SCORE 1
R      HELP
GWE SAID A RELATION WAS A SET OF ORDERED PAIRS
BNO. WE SAID A RELATION WAS A SET OF ORDERED PAIRS.
AA     RESCAN, SCORE 2
C
CIS *ANTHONY,CLEOPATRA* *LYNDON,LADY BIRD* *ADAM,EVE* A RELATIONQ
R      YES
GYOURE RIGHT
AA     RSKIP 1, SCORE 1
R      HELP
GYES IT IS. IT IS A SET OF ORDERED PAIRS AND REPRESENTS THE RELATION
G(HUSBAND,WIFE).
BYES IT IS TOO. IT IS A SET OF ORDERED PAIRS AND REPRESENTS THE RE
BLATION (HUSBAND,WIFE).
AA     RESCAN, SCORE 2
```

```
C
CTHE CONCEPT OF RELATIONS THEN INVOLVES A RULE WHEREBY AN ARBITRARY
CORDERED PAIR CAN BE CLASSIFIED AS BELONGING OR NOT BELONGING TO
CTHE •••
R       RELATION
GCORRECT
AA      RSKIP 1, SCORE 1
R       HELP
GWELL, YOU SHOULD KNOW ITS RELATION.
BNO. YOU SHOULD KNOW ITS RELAATION
AA      RESCAN, SCORE 2
CI BELIEVE WE WILL STOP FOR NOW. YOUR SCORE IS AS FOLLOWS.
E       TSCORES, TTABLE
```

APPENDIX C

CHOOSE THE BEST RESPONSE FROM THOSE GIVEN.

1. A binary relation is...
   1. a set of numbers
   2. a pair of numbers
   3. a set of pairs of numbers
   4. a graph

2. An example of the relation (n 7,n) is...
   1. (7,7)
   2. (0,7)
   3. (1,8)
   4. (7,0)

3. Which of the pairs of numbers below belongs to the relation with the first element three times the second element?
   1. (1,3)
   2. (4,1)
   3. (0,3)
   4. none of the above

4. The word "binary" as it was used in the study of relations refers to...
   1. two numbers
   2. binary numbers
   3. a pair of elements
   4. two sets

5. The order in which elements appear in a binary relation...
   1. is not reversable
   2. makes little difference
   3. determines the degree of the relation
   4. none of the above

6. Which of the sets below is a relation?
   1. (1,2,3,4), (3,1,2,4)
   2. (shoes,socks), (coats,shirts)
   3. (triangles) (squares), (rectangles) (circles)
   4. none of the above

7. Which of the following does <u>not</u> belong to the binary relation "has the same value as"?
   1. (10 pennies, 1 dime)
   2. (2 dimes, 4 nickels)
   3. (1 dime, 2 nickels, 10 pennies)
   4. All of the above

8. The relation with the second number 5 larger than the first could be...
   1. (n,n-5)
   2. (n-5,n)
   3. (n,5n)
   4. none of the above

9. The set {1,1,2,2,3,3,} is...
   1. a binary relation
   2. not a binary relation
   3. a set of ordered pairs
   4. none of the above

10. The concept of a relation...
   1. depends on order
   2. involves a rule
   3. involves a set
   4. all of the above

11. The set of the 10 best-dressed men in the U.S. is...
   1. well defined
   2. not well defined
   3. a binary relation
   4. none of the above

APPENDIX D

STUDENT ATTITUDE TOWARD COMPUTER ASSISTED INSTRUCTION

COMMUNICATION SKILLS

This is not a test of information; therefore, there is no one "right" answer to a question. We are interested in your opinion on each of the statements below. Your opinions will be strictly confidential. Do not hesitate to put down exactly how you feel about each item. We are seeking information, not compliments; please be frank.

NAME: _____ DATE _____

NAME OF COURSE _____

CIRCLE THE RESPONSE THAT MOST NEARLY REPRESENTS YOUR REACTION TO EACH OF THE STATEMENTS BELOW:

1. While taking Computer Assisted Instruction I felt challenged to do my best work.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

2. The material presented to me by Computer Assisted Instruction caused me to feel that no one really cared whether I learned or not.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

3. The method by which I was told whether I had givern a right or wrong answer became monotonous.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

4. I was concerned that I might not be understanding the material.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

5. I was not concerned when I missed a question because no one was watching me anyway.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

6. While taking Computer Assisted Instruction I felt isolated and alone.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

7. While taking Computer Assisted Instruction I felt as if someone were engaged in conversation with me.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

8. The responses to my answers seemed appropriate.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

9. I felt uncertain as to my performance in the programmed course relative to the performance of others.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

10. I found myself just trying to get through the material rather than trying to learn.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

11. I knew whether my answer was correct or not before I was tole.

:	:	:	:	:
Quite often	Often	Occasionly	Seldom	Very seldom

12. I guessed at the answers to questions.

:	:	:	:	:
Quite often	Often	Occasionly	Seldom	Very seldom

13. In a situation where I am trying to learn something, it is important to me to know where I stand relative to others.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

14. I was encouraged by the responses given to my answers of questions.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

15. As a result of having studied some material by Computer Assisted Instruction, I am interested in trying to find out more about the subject matter.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

16. In view of the time allowed for learning, I felt too much material was presented.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

17. I was more involved in running the machine than in understanding the material.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

18. I felt I could work at my own pace with Computer Assisted Instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

19. Computer Assisted Instruction makes the learning too mechanical.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

20. I felt as if I had a private tutor while on Computer Assisted Instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

21. I was aware of efforts to suit the material specifically to me.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

22. I found it difficult to concentrate on the course material because of the hardware.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

23. The Computer Assisted Instruction situation made me feel quite tense.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

24. Questions were asked which I felt were not relevant to the material presented.

:	:	:	:	:
All the time	Most of the time	Some of the time	Only occasionly	Never

25. Computer Assisted Instruction is an inefficient use of the student's time.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

26. I put in answers knowing they were wrong in order to get information from the machine.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

27. Concerning the course material I took by Computer Assisted Instruction, my feeling toward the material before I came to Computer Assisted Instruction was:

:	:	:	:	:
Very Favorable	Favorable	Indifferent	Unfavorable	Very Unfavorable

28. Concerning the course material I took by Computer Assisted Instruction, my feeling toward the material after I have been on Computer Assisted Instruction is:

:	:	:	:	:
Very Favorable	Favorable	Indifferent	Unfavorable	Very Unfavorable

29. I was given answers but still did not understand the questions.

:	:	:	:	:
Very often	Often	Occasionly	Seldom	Very Seldom

30. While on Computer Assisted Instruction I encountered mechanical malfunctions.

:	:	:	:	:
Very often	Often	Occasionly	Seldom	Very Seldom

31. Computer Assisted Instruction made it possible for me to learn quickly.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

32. I felt frustrated by the Computer Assisted Instruction situation.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

33. The responses to my answers seemed to take into account the difficulty of the questior

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

34. I could have learned more if I hadn't felt pushed.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

35. The Computer Assisted Instruction approach is inflexible.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

36. Even otherwise interesting material would be boring when presented by Computer Assisted Instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

37. In view of the effort I put into it, I was satisfied with what I learned while taking Computer Assisted Instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

38. In view of the amount I learned, I would say Computer Assisted Instruction is superior to traditional instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

39. With a course such as I took by Computer Assisted Instruction, I would prefer Computer Assisted Instruction to traditional instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

40. I am not in favor of Computer Assisted Instruction because it is just another step toward de-personalized instruction.

:	:	:	:	:
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

APPENDIX E

Instructions to the subject:

"This is an experiment using the computer as a teaching device. The computer will present information to you, ask you questions about that information, and then you will type the answer to those questions. Now the computer will present small amounts of information at the time and if you pay close attention to the material, you shouldn't have any trouble answering most of the questions."

(Demonstrate how to operate, correct for misspelling, and use help sequence).

"Are there any questions"?

APPENDIX F

Item Analysis of Test Scores

ITEM	1	Diff. .70	Disc.	.34
ITEM	2	Diff. .60	Disc.	.22
ITEM	3	Diff. .61	Disc.	.27
ITEM	4	Diff. .71	Disc.	.08
ITEM	5	Diff. .43	Disc.	.42
ITEM	6	Diff. .52	Disc.	.35
ITEM	7	Diff. .42	Disc.	.21
ITEM	8	Diff. .45	Disc.	.63
ITEM	9	Diff. .15	Disc.	.28
ITEM	10	Diff. .61	Disc.	.01
ITEM	11	Diff. .83	Disc.	.03

As far as the difficulty of an item, good items have an index of approximately .50. As can be seen, all items were of appropriate difficulty except items nine and eleven.

Items that are considered good discriminators should have indexes of approximately .25. As can be seen, all items were acceptable except items four, ten, and eleven.